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Paper Session III-C - Solar Power in Space

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Solar Power in Space
By John Perlin

The space program could not have existed without the solar cells and its twin, the transistor. Almost all satellites ever launched have relied on these two semiconductor devices to operate. Solar cells convert sunlight directly into electricity. No more than several hundred microns thick, they produce electricity without boilers, turbines, pipes and cooling towers. In fact, they work without moving parts. Photons, packets of energy from the sun, silently split loosely bound electrons in the solar material from their orbits. The solar cell's intrinsic voltage pushes those liberated electrons in its vicinity to contacts where they flow through as electricity. The modularity of the technology called photovoltaics allows technicians to exactly fit the amount of solar cells to the application at hand whether requiring a milliwatt or megawatts of power.

Since the 1870s scientists have known that certain solid materials can produce electricity directly from sunlight. The discovery of the first material able to generate enough power directly from sunlight to run electrical equipment occurred in the early 1950s. Scientists at Bell Laboratories accidentally devised a very efficient solar cell while working on semiconductor research that has revolutionized electronics. Bell Laboratories presciently recognized the significance of both their twin discoveries - the silicon solar cell and the silicon transistor, stating that these two Bell inventions "will be closely linked in many important future developments that will profoundly influence the art of living." Satellites became the first technology to prove this expectation true.

When Bell Laboratories presented to the public the world's first highly efficient solar cells, the Army and Air Force took immediate notice. Both branches of the military viewed them as the logical source of power for a top- secret device – an earth orbiting satellite – they planned to launch in the immediate future. The late Dr. Hans Ziegler, the Army's lead electronics investigator at the time, took a particular interest. After visiting Bell Laboratories several times, he came to the conclusion that "In the long run, mankind has no choice but to turn to the sun if he wants to survive." In the near future, though, Dr. Ziegler could see but one application – powering satellites. Freed from terrestrial restraints on solar radiation, namely inclement weather and nighttime, "operations above the earth's atmosphere would provide ideal circumstances" for solar cells, one of Ziegler's colleagues at the Signal Corps concluded. Solar cells had other advantages over any other power source considered for satellites. An extremely lightweight solar array could provide the small amount of power that the transistorized communication equipment onboard required without encumbering the payload. Also, silicon solar cells would last a very long time, unlike the other power option – batteries – which would surely quit working within a week or two. Ziegler and his colleagues therefore concluded in their highly classified report to the Department of Defense, "For longer periods of operation and limited allowance of weight, the photovoltaic principle appears most promising."

The dream of launching a solar powered satellite came closer to fact on July 30, 1955, when President Eisenhower announced America's plan to put a satellite into space. A drawing that accompanied Eisenhower's front-page statement in newspapers throughout the nation showed silicon solar cells as the satellite's power source.

Selecting the Navy to launch America's first satellite threw a snag in introducing solar power in Space. From the start, the Navy had ruled out the use of solar cells, judging them as "unconventional and not fully established." In Ziegler's opinion, following the logic of the

Navy's decision, "the whole space effort should be scrapped since no one had ever attempted to launch a satellite either."

The Navy's refusal to yield on the solar issue drove Ziegler to conduct a one-man crusade to reverse the Navy's adamant stand. Ziegler's burning zeal "To give mankind the benefit of solar cells at the earliest possible time" overrode any observance of protocol expected from someone in Ziegler's position. He therefore had no qualms about taking his case to another forum, the "Technical Panel on the Earth Satellite Program," a group of prominent civilian scientists who oversaw the development of America's fledgling space program, embraced Ziegler's ideas enthusiastically. The panel shared Ziegler's disdain for relying on batteries for powering satellites because they would automatically limit "most of the on-board apparatus to an active life of only a few weeks while nearly all of the experiments" in space which would "have enormously greater value if they could be kept operating for several months or more."

Relenting to pressure from the panel, the Naval Research Laboratory invited the Ziegler and his colleagues at the Signal Corps to participate in the satellite program code named Project Vanguard and assigned them the responsibility of designing a solar cell power system. Receiving the go ahead, Ziegler and staff quickly developed prototype modules robust enough to survive the vicissitudes of space travel. To test their actual performance in real life situations, the Signal Corps, in cooperation with the Navy, attached its solar equipment to the nose cones of two Aerobee rockets. The cells performed perfectly. Still, the Navy did everything to obstruct their use in Space, announcing after these successful trials, "At least the first four satellites probably will have conventional chemical batteries as their power source."

The Vanguard program became mired in problems that resulted in delays. To get something launched, the Navy decided to put a number of grapefruit-sized spheres into orbit minus all the electronics except for a transmitter. The altered plans, according to Ziegler, presented a new opportunity to give our solar power supplies a free ride," since the change in plans had freed a considerable amount of weight the satellite would have otherwise carried.

The first satellite with solar cells aboard went into orbit on St. Patrick's Day, 1958. The Navy having little faith in the solar component also installed chemical batteries. These gave out nineteen days later and then solar power kicked in, keeping the transmitter beeping for many years. The solar run Vanguard satellite proved far more valuable to science than the first two much larger Soviet satellites. Their reliance on conventional batteries caused them to shut down operations after a week or so in space. Long-lasting communications between the Vanguard and Earth thanks to solar power enabled scientists to discover the true shape of the earth. After a while the Vanguard's continued noise proved a nuisance but no one could do anything about it. The Navy felt so sure the solar cells would not work they did not deem it necessary to install any mechanism to turn the transmitter off!

Sputnik III, launched three weeks after the first Vanguard, became the first Russian satellite to have its telemetry system powered by solar cells. Despite the success of solar power on the Vanguard and Sputnik III, many in the space business still considered solar cells as nothing more than a stopgap measure, a technology to use until nuclear power would take over. People worried that solar would not provide enough power for the larger space probes in the works. Nuclear though never delivered the performance, the reliability and the safety that people had anticipated. In contrast, the pessimism held toward solar's power capability proved wrong. Solar engineers came up with ingenious designs to ramp up power delivery from milliwatts to over sixty kilowatts. Everyone knowledgeable about space came to accept the solar cell as one of the critically important devices in the space program since it provided the only practical power source in Space for satellites orbiting reasonably close to the sun.

The urgent demand for solar cells above the earth opened an unexpected and relatively large business for their manufacture. More importantly, for the first time in human history solar energy has played a critical role in society. Powering every satellite in the sky has made solar cells indispensable. Since the war in the Persian Gulf, solar-powered satellites have directed battle operations in all of America's major conflicts including the present one in Afghanistan. In the words of General Lester Lyles, Air Force Material Command Commander, "No American military force could fight without the use of space based assets." Satellites run much of civilian life as well. They orchestrate the harmonious meshing of a multitude of disparate networks for seamless wireless communicating. Satellites have contributed to the spread of purchasing with electronic money by allowing companies to bypass much slower and more tedious phone links. Those moving people or moving goods in the air, on land or by sea depend on satellites to stay on course. Thanks to satellites, operators at fixed sites can stay in touch with mobile resources. Data control by satellites keeps companies in intimate contact with their far-flung holdings throughout the globe. Live television footage from across the sea did not exist until communication satellites came of age. Now all on-the-scene live TV reporting feeds into satellites. Likewise, satellites sired Cable and Direct TV. Satellites will soon speed up the internet by unclogging portions of the information highway prone to gridlock. Summing up the importance of the sun's energy for Space, Dr. Ziegler succinctly concluded twenty years after the little Vanguard broke the ice, "Not much of our past, present, or future use of Space would have been possible" without solar cells.